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Synchronizing device for a shift transmission

The invention relates to a synchronizing device for a shift transmission, with at least one outer and one inner synchro ring and, if appropriate, an intermediate ring, of the type defined in more detail in the pre-characterizing clause of Claim 1.

DE 31 22 522 A1 discloses a generic synchronizing device.

In this case, a friction lining consisting of a non-metallic inorganic material is applied to one of the friction partners, to be precise either to a synchro ring or to a synchronizing ring, and is intended to improve the friction properties between the friction partners.

However, disadvantages of the method for producing this synchronizing device are that it is very costly and the applied friction lining has to be either applied extremely carefully or remachined after application. This leads to complicated manufacturing cycles and, furthermore, the friction lining may be damaged during retreatment.

Another problem of this known synchronizing device is that particles, such as, for example, sulphur particles which reduce the coefficient of friction and are contained in the transmission oil may settle in the applied friction layer. As a

result of these sulphur particles, the coefficient of friction between the friction partners is reduced, and therefore the applicable synchronizing torque or the synchronizing power of the shift transmission is diminished. This may ultimately lead to serious malfunctions of the transmission.

For the further prior art relating to synchronizing devices for shift transmissions, reference is made to FR 15 21 621 and JP 2-304220 A.

The object of the present invention is to provide a synchronizing device for a shift transmission, which ensures uniform friction conditions between the friction partners and which at the same time can be produced simply and cost-effectively.

This object is achieved, according to the invention, by means of the features mentioned in the characterizing clause of Claim 1.

By means of the nitride hardening according to the invention of the synchro ring and/or of the intermediate ring consisting of the metallic basic material, as a result of which hardening a non-metallic γ'-connecting layer and/or a non-metallic ε-connecting layer is formed on the conical surface, for one of the friction partners in each case an outer frictional surface is obtained which has a constant coefficient of friction at a desired high level. In this case, the nitrided surface at the same time has high hardness and high wear resistance

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associated with this. Furthermore, as a result of the nitride hardening, a non-hardened and therefore tough core remains, which ensures the strength of the respective component.

According to the invention, then, sulphur particles and other additives reducing the coefficient of friction can no longer penetrate into the γ'-connecting layer or into the ε-connecting layer, thus ensuring a uniformly high synchronizing moment. In order to form said connecting layers, it is necessary merely to change specific process parameters during nitride hardening, so that this layer is formed without an additional method step. Remachining of the corresponding connecting layer is advantageously no longer necessary. A very simple and cost-effective production of the synchronizing device is thus achieved.

In this case, the γ'-connecting layer or ε-connecting layer is firmly connected to the basic material of the synchro ring or of the intermediate ring, since it is not an injected-on or otherwise applied layer, but a layer produced by transformation from the basic material of the component.

Advantageous refinements and developments of the invention may be gathered from the subclaims and from the exemplary embodiment illustrated in principle below with reference to the drawing in which:

Figure 1 shows a highly diagrammatic illustration of part of a shift transmission with a synchronizing device according to the invention;

Figure 2 shows a top view of an outer synchro ring of the synchronizing device from Figure 1;

Figure 3 shows a section along the line III-III from Figure 2;

Figure 4 shows a top view of an inner synchro ring of the synchronizing device from Figure 1; and

Figure 5 shows a section along the line V-V from Figure 4.

Figure 1 shows a shift transmission, for example for use in heavy goods vehicles or passenger cars, which is not illustrated in its entirety. The shift transmission has, in a way known per se, a synchronizing device 1, a main shaft 2 and a gearwheel 3 mounted on the main shaft 2. Other gearwheels are also mounted on the main shaft 2, of course, but, since these are not relevant to the invention, they are not described below in any more detail. Nor is a countershaft conventionally used in the shift transmissions illustrated in Figure 1. A synchro body 4 is also located on the main shaft 2, in addition to the gearwheel 3, and is connected to a sliding fork 5 via a sliding sleeve 6

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and a thrust pin 7. It is also possible, of course, for the components located on the main shaft 2 to be mounted on the countershaft.

The synchro body 4 is connected to the gearwheel 3 by the synchronizing device 1. For this purpose, the synchronizing device 1 consists of an outer synchro ring 8, an intermediate ring 9 and an inner synchro ring 10, the outer synchro ring 8 being connected to the synchro body 4 and the inner synchro ring 10 to the gearwheel 3. This design of the synchronizing device 1 is known per se and is also designated as Borg-Warner double-cone synchronization. Since the synchronization of the individual gearwheels of the shift transmission also proceeds in the same way in the present embodiment of the synchronizing device 1 as is known from the prior art, these sequences are not discussed in any more detail below.

The outer synchro ring 8 illustrated in more detail in Figures 2 and 3 has a conical surface 11 on its inside diameter, whereas the inner synchro ring 10 illustrated in Figures 4 and 5 is provided with a conical surface 12 on its outside diameter. The intermediate ring 9 arranged between the outer synchro ring 8 and the inner synchro ring 10 has an entirely conical design, that is to say both its outside diameter and its inside diameter are designed as conical surfaces 13 and 14 and are adapted to the conical surfaces 11 and 12 of the synchro rings 8 and 10. The synchronizing device 1 is provided for transmitting a force or

a torque from the synchro body 4 to the gearwheel 3 via the outer synchro ring 8, the intermediate ring 9 and the inner synchro ring 10 by means of friction between the respective conical surfaces 11 to 14.

In order to achieved the desired coefficient of friction between the conical surface 13 on the outside diameter of the intermediate ring 9 and the conical surface 11 on the inside diameter of the outer synchro ring 8 and between the conical surface 14 of the intermediate ring 9 and the conical surface 12 of the inner synchro ring 10, the intermediate ring 9 is first provided on both conical surfaces 13 and 14 with a friction layer known per se.

Both the outer synchro ring 8 and the inner synchro ring 10 are nitride-hardened on their conical surfaces 11 and 12. This nitride hardening is preferably carried out by means of a plasma-nitriding method, in which the process parameters are set such that non-metallic so-called γ'-connecting layers or ε-connecting layers are formed on the conical surfaces 11 and 12. For this purpose, the outer synchro ring 8 and the inner synchro ring 10 are introduced into a nitriding furnace, not illustrated, in which an ammonia atmosphere prevails. The process parameters to be set for the formation of the γ'-connecting layer or ε-connecting layer are, in this case, the temperature in the nitriding furnace, the gas mixture within the nitriding furnace, consisting of ammonia, hydrogen and carbon dioxide, the duration

of the nitriding treatment, the vacuum prevailing in the nitriding furnace and the plasma which is necessary during plasma nitriding and which is controlled by a current and voltage. A layer is thus obtained in each case on the conical surfaces 11 and 12, which, on the one hand, is very hard and wear-resistant and into which, on the other hand, no additives, such as, for example, sulphur particles, contained in the transmission oil and reducing the coefficient of friction can infiltrate. As a result, a constant coefficient of friction is maintained continuously for the conical surfaces 11 and 12 and a uniform synchronizing torque can be transmitted by the synchronizing device 1.

The nitriding depth of the conical surfaces 11 and 12 is about 200 to 800 μm and the γ'-connecting layer or ε-connecting layer is approximately 1 to 20 μm, preferably approximately 10 μm, thick. The γ'-connecting layer is an iron/nitrogen layer with the chemical designation Fe_4N. By contrast, the ε-connecting layer consists of the iron/nitrogen layer bearing the chemical designation $Fe_{2-3}N$.

Instead of the nitriding treatment of the outer synchro ring 8 and of the inner synchro ring 10, alternatively the intermediate ring 9 may also be nitride-hardened on its two conical surfaces 13 and 14 by means of the plasma-nitriding method, as described above, in this case, of course, the friction layer being applied to the conical surfaces 11 and 12 of the synchro rings 8 and 10. Furthermore, the principle of plasma-

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nitride hardening also operates with regard to single-cone synchronization without the intermediate ring 9, and, in this case, it is necessary merely to treat a conical surface of one of the two synchro rings 8 and 10 by means of a plasma-nitriding method.

The metallic basic material of the synchro rings 8 and 10 or of the intermediate ring 9 may be a sintered material, a sinter-forged material or else a hardenable steel, such as, for example, 16MnCr5, 31CrMoV9 or 34CrAlNi7. In the present exemplary embodiment, the synchro rings 8 and 10 are sintered parts. It is particularly advantageous to use molybdenum as a basic alloying element in these sintered materials, whereas, if steel materials are used, the alloying constituents chromium, molybdenum, aluminium and manganese lead to very good results.

Instead of plasma nitriding, if appropriate the nitriding methods used may also be long-term gas nitriding or short-term gas nitriding.

Of course, the synchronizing device 1 could also be designed for single-cone synchronization or for three-cone or multiple-cone synchronization, instead of for Borg-Warner double-cone synchronization.

In single-cone synchronization according to the Borg-Warner system, there would be no intermediate ring 9 provided, the outer synchro ring 8 would be produced in one part with the gearwheel 3 and the inner synchro ring 8 would be connected to

the synchro body 4. The γ'-connecting layer or the ε-connecting layer would then be provided on one of the two synchro rings 8 or 10 and the friction layer on the other.

In further possible single-cone synchronization, the conical surface 11 could be mounted on the sliding sleeve 6, in which case the inner synchro ring 10 would be mounted loosely on the gearwheel 3. The γ'-connecting layer or the ε-connecting layer and the friction layer could then be applied to the conical surface 11 of the sliding sleeve 6 or to the conical surface 12 of the inner synchro ring 10.

In the case of triple-cone synchronization, two intermediate rings 9 would have to be provided, in which case the γ'-connecting layer or the ε-connecting layer and the friction layer would have to be applied in accordance with the embodiments mentioned above. In the case of multiple-cone synchronization, a correspondingly larger number of intermediate rings 9 is necessary.